

## Power MOSFET

**TO-220 FULLPAK**


N-Channel MOSFET

### FEATURES

- Isolated package
- High voltage isolation = 2.5 kV<sub>RMS</sub> (t = 60 s; f = 60 Hz)
- Sink to lead creepage distance = 4.8 mm
- 175 °C operating temperature
- Dynamic dV/dt rating
- Low thermal resistance
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


**RoHS**  
COMPLIANT

### DESCRIPTION

Third generation power MOSFETs from Vishay provides the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost effectiveness.

The TO-220 FULLPAK eliminates the need for additional insulating hardware in commercial-industrial applications. The molding compound used provides a high isolation capability and a low thermal resistance between the tab and external heatsink. This isolation is equivalent to using a 100 micron mica barrier with standard TO-220 product. The FULLPAK is mounted to a heatsink using a single clip or by a single screw fixing.

### PRODUCT SUMMARY

|                            |                        |      |
|----------------------------|------------------------|------|
| V <sub>DS</sub> (V)        | 60                     |      |
| R <sub>DS(on)</sub> (Ω)    | V <sub>GS</sub> = 10 V | 0.10 |
| Q <sub>g</sub> (Max.) (nC) | 25                     |      |
| Q <sub>gs</sub> (nC)       | 5.8                    |      |
| Q <sub>gd</sub> (nC)       | 11                     |      |
| Configuration              | Single                 |      |

### ORDERING INFORMATION

|                |                |
|----------------|----------------|
| Package        | TO-220 FULLPAK |
| Lead (Pb)-free | IRFIZ24GPbF    |

### ABSOLUTE MAXIMUM RATINGS T<sub>C</sub> = 25 °C, unless otherwise noted

| PARAMETER                                                 | SYMBOL                            | LIMIT                   | UNIT |
|-----------------------------------------------------------|-----------------------------------|-------------------------|------|
| Drain-source voltage                                      | V <sub>DS</sub>                   | 60                      | V    |
| Gate-source voltage                                       | V <sub>GS</sub>                   | ± 20                    |      |
| Continuous drain current                                  | V <sub>GS</sub> at 10 V           | T <sub>C</sub> = 25 °C  | A    |
|                                                           |                                   | T <sub>C</sub> = 100 °C |      |
| Pulsed drain current <sup>a</sup>                         | I <sub>DM</sub>                   | 56                      |      |
| Linear derating factor                                    |                                   | 0.24                    | W/°C |
| Single pulse avalanche energy <sup>b</sup>                | E <sub>AS</sub>                   | 100                     | mJ   |
| Maximum power dissipation                                 | P <sub>D</sub>                    | 37                      | W    |
| Peak diode recovery dV/dt <sup>c</sup>                    | dV/dt                             | 4.5                     | V/ns |
| Operating junction and storage temperature range          | T <sub>J</sub> , T <sub>stg</sub> | -55 to +175             | °C   |
| Soldering recommendations (peak temperature) <sup>d</sup> | For 10 s                          | 300                     |      |
| Mounting torque                                           | M3 screw                          | 0.6                     | Nm   |

#### Notes

a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)

b. V<sub>DD</sub> = 25 V, starting T<sub>J</sub> = 25 °C, L = 595 μH, R<sub>G</sub> = 25 Ω, I<sub>AS</sub> = 14 A (see fig. 12)

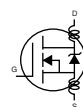
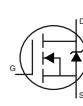
c. I<sub>SD</sub> ≤ 17 A, dI/dt ≤ 140 A/μs, V<sub>DD</sub> ≤ V<sub>DS</sub>, T<sub>J</sub> ≤ 175 °C

d. 1.6 mm from case

**THERMAL RESISTANCE RATINGS**

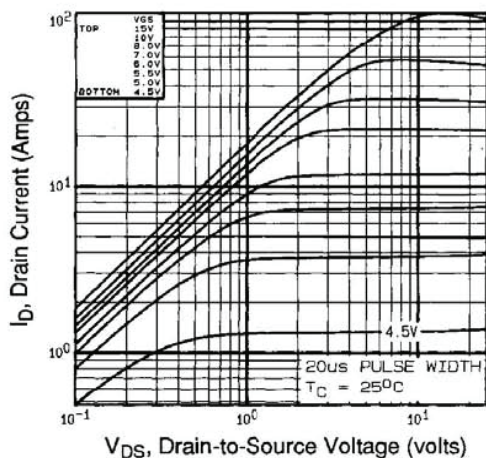
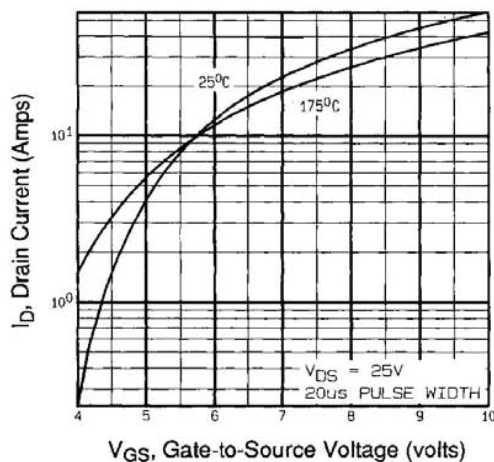
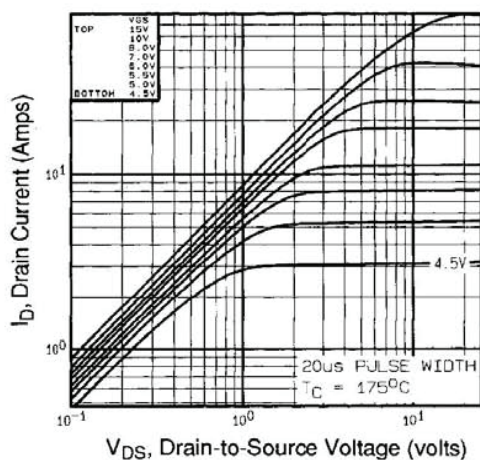
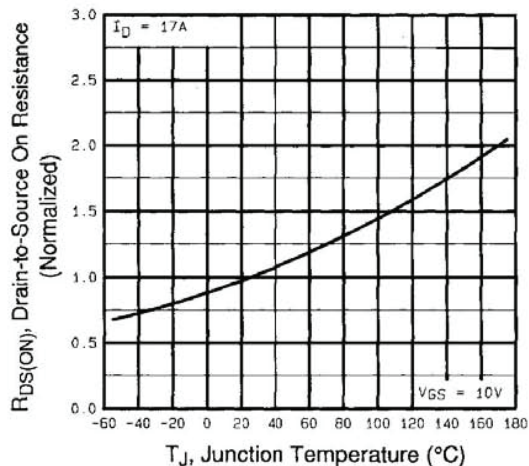
| PARAMETER                        | SYMBOL     | TYP. | MAX. | UNIT |
|----------------------------------|------------|------|------|------|
| Maximum junction-to-ambient      | $R_{thJA}$ | -    | 65   | °C/W |
| Maximum junction-to-case (drain) | $R_{thJC}$ | -    | 4.1  |      |

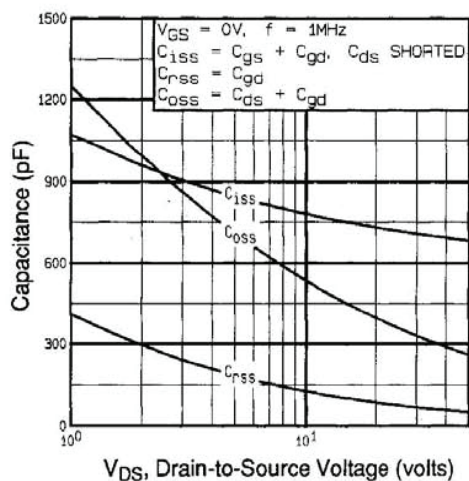
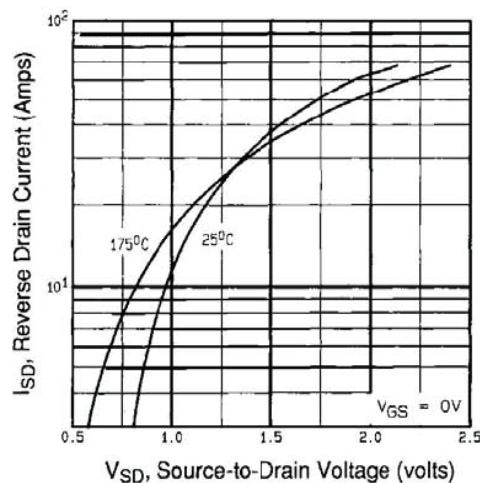
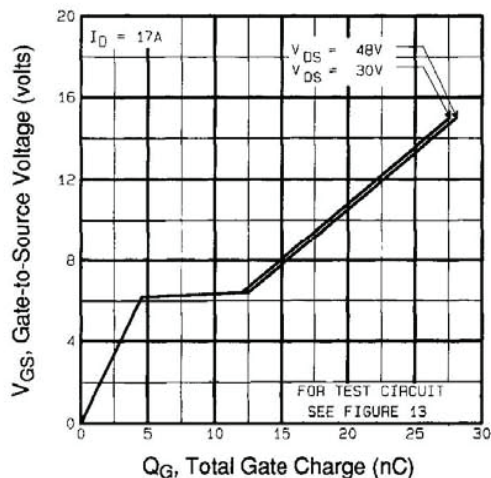
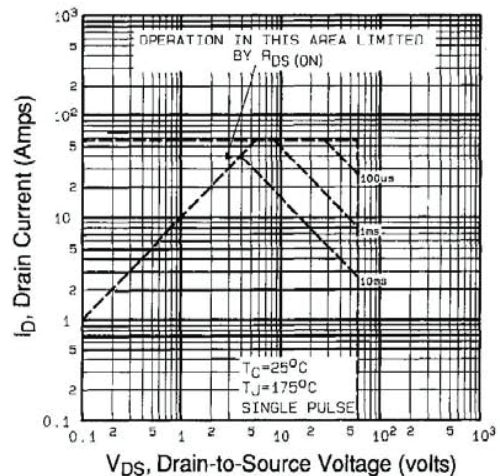
**SPECIFICATIONS**  $T_J = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted

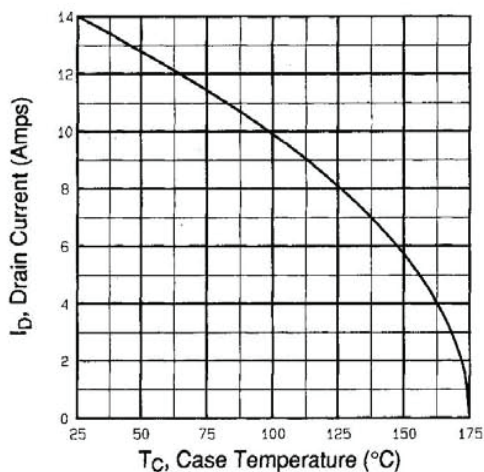
| PARAMETER                                 | SYMBOL              | TEST CONDITIONS                                                                                                                      |                                                                                  | MIN.                                                                                  | TYP.  | MAX.      | UNIT                  |    |    |
|-------------------------------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|-------|-----------|-----------------------|----|----|
| Static                                    |                     |                                                                                                                                      |                                                                                  |                                                                                       |       |           |                       |    |    |
| Drain-ssource breakdown voltage           | $V_{DS}$            | $V_{GS} = 0\text{ V}$ , $I_D = 250\text{ }\mu\text{A}$                                                                               |                                                                                  | 60                                                                                    | -     | -         | V                     |    |    |
| $V_{DS}$ temperature coefficient          | $\Delta V_{DS}/T_J$ | Reference to $25\text{ }^{\circ}\text{C}$ , $I_D = 1\text{ mA}$                                                                      |                                                                                  | -                                                                                     | 0.061 | -         | V/ $^{\circ}\text{C}$ |    |    |
| Gate-source threshold voltage             | $V_{GS(th)}$        | $V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$                                                                                   |                                                                                  | 2.0                                                                                   | -     | 4.0       | V                     |    |    |
| Gate-source leakage                       | $I_{GSS}$           | $V_{GS} = \pm 20\text{ V}$                                                                                                           |                                                                                  | -                                                                                     | -     | $\pm 100$ | nA                    |    |    |
| Zero gate voltage drain current           | $I_{DSS}$           | $V_{DS} = 60\text{ V}$ , $V_{GS} = 0\text{ V}$                                                                                       |                                                                                  | -                                                                                     | -     | 25        | $\mu\text{A}$         |    |    |
|                                           |                     | $V_{DS} = 48\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 150\text{ }^{\circ}\text{C}$                                                 |                                                                                  | -                                                                                     | -     | 250       |                       |    |    |
| Drain-source on-state resistance          | $R_{DS(on)}$        | $V_{GS} = 10\text{ V}$                                                                                                               | $I_D = 8.4\text{ A}^b$                                                           | -                                                                                     | -     | 0.10      | $\Omega$              |    |    |
| Forward transconductance                  | $g_{fs}$            | $V_{DS} = 25\text{ V}$ , $I_D = 8.4\text{ A}^b$                                                                                      |                                                                                  | 5.8                                                                                   | -     | -         | S                     |    |    |
| Dynamic                                   |                     |                                                                                                                                      |                                                                                  |                                                                                       |       |           |                       |    |    |
| Input capacitance                         | $C_{iss}$           | $V_{GS} = 0\text{ V}$ ,<br>$V_{DS} = 25\text{ V}$ ,<br>$f = 1.0\text{ MHz}$ , see fig. 5                                             |                                                                                  | -                                                                                     | 640   | -         | pF                    |    |    |
| Output capacitance                        | $C_{oss}$           |                                                                                                                                      |                                                                                  | -                                                                                     | 360   | -         |                       |    |    |
| Reverse transfer capacitance              | $C_{rss}$           |                                                                                                                                      |                                                                                  | -                                                                                     | 79    | -         |                       |    |    |
| Drain to sink capacitance                 | $C$                 | $f = 1.0\text{ MHz}$                                                                                                                 |                                                                                  | -                                                                                     | 12    | -         |                       |    |    |
| Total gate charge                         | $Q_g$               | $V_{GS} = 10\text{ V}$                                                                                                               | $I_D = 17\text{ A}$ , $V_{DS} = 48\text{ V}$ ,<br>see fig. 6 and 13 <sup>b</sup> | -                                                                                     | -     | 25        | nC                    |    |    |
| Gate-source charge                        | $Q_{gs}$            |                                                                                                                                      |                                                                                  | -                                                                                     | -     | 5.8       |                       |    |    |
| Gate-drain charge                         | $Q_{gd}$            |                                                                                                                                      |                                                                                  | -                                                                                     | -     | 11        |                       |    |    |
| Turn-on delay time                        | $t_{d(on)}$         | $V_{DD} = 30\text{ V}$ , $I_D = 17\text{ A}$ ,<br>$R_G = 18\text{ }\Omega$ , $R_D = 1.7\text{ }\Omega$ ,<br>see fig. 10 <sup>b</sup> |                                                                                  | -                                                                                     | 13    | -         | ns                    |    |    |
| Rise time                                 | $t_r$               |                                                                                                                                      |                                                                                  | -                                                                                     | 58    | -         |                       |    |    |
| Turn-off delay time                       | $t_{d(off)}$        |                                                                                                                                      |                                                                                  | -                                                                                     | 25    | -         |                       |    |    |
| Fall time                                 | $t_f$               |                                                                                                                                      |                                                                                  | -                                                                                     | 42    | -         |                       |    |    |
| Internal drain inductance                 | $L_D$               | Between lead,<br>6 mm (0.25") from<br>package and center of<br>die contact                                                           |                                                                                  |  |       | -         | 4.5                   | -  | nH |
| Internal source inductance                | $L_S$               |                                                                                                                                      |                                                                                  |                                                                                       |       | -         | 7.5                   | -  |    |
| Drain-Source Body Diode Characteristics   |                     |                                                                                                                                      |                                                                                  |                                                                                       |       |           |                       |    |    |
| Continuous source-drain diode current     | $I_S$               | MOSFET symbol<br>showing the<br>integral reverse<br>p - n junction diode                                                             |                                                                                  |  |       | -         | -                     | 14 | A  |
| Pulsed diode forward current <sup>a</sup> | $I_{SM}$            |                                                                                                                                      |                                                                                  |                                                                                       |       | -         | -                     | 56 |    |
| Body diode voltage                        | $V_{SD}$            | $T_J = 25\text{ }^{\circ}\text{C}$ , $I_S = 14\text{ A}$ , $V_{GS} = 0\text{ V}^b$                                                   |                                                                                  | -                                                                                     | -     | 1.5       | V                     |    |    |
| Body diode reverse recovery time          | $t_{rr}$            | $T_J = 25\text{ }^{\circ}\text{C}$ , $I_F = 17\text{ A}$ , $dI/dt = 100\text{ A}/\mu\text{s}^b$                                      |                                                                                  | -                                                                                     | 90    | 180       | ns                    |    |    |
| Body diode reverse recovery charge        | $Q_{rr}$            |                                                                                                                                      |                                                                                  | -                                                                                     | 0.32  | 0.64      | $\mu\text{C}$         |    |    |
| Forward turn-on time                      | $t_{on}$            | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S$ and $L_D$ )                                                      |                                                                                  |                                                                                       |       |           |                       |    |    |

**Notes**

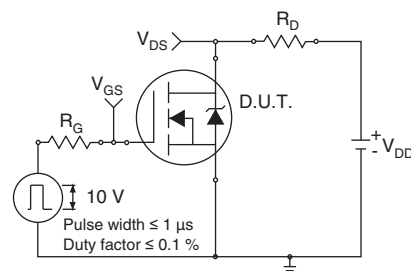
- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)  
b. Pulse width  $\leq 300\text{ }\mu\text{s}$ ; duty cycle  $\leq 2\%$

**TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted

**Fig. 1 - Typical Output Characteristics,  $T_C = 25^\circ\text{C}$** 

**Fig. 3 - Typical Transfer Characteristics**

**Fig. 2 - Typical Output Characteristics,  $T_C = 175^\circ\text{C}$** 

**Fig. 4 - Normalized On-Resistance vs. Temperature**


**Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage**

**Fig. 7 - Typical Source-Drain Diode Forward Voltage**

**Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage**

**Fig. 8 - Maximum Safe Operating Area**



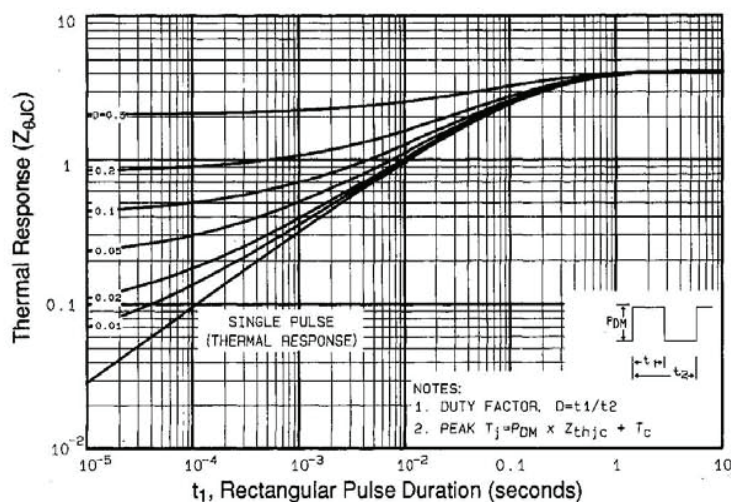
**Fig. 9 - Maximum Drain Current vs. Case Temperature**



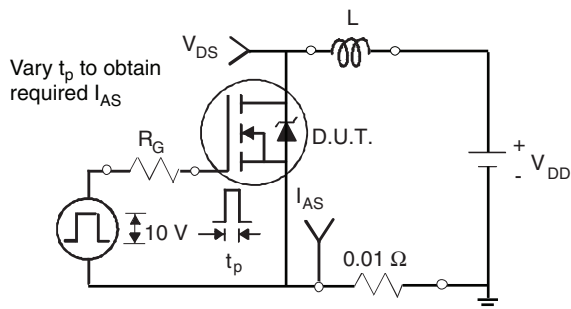
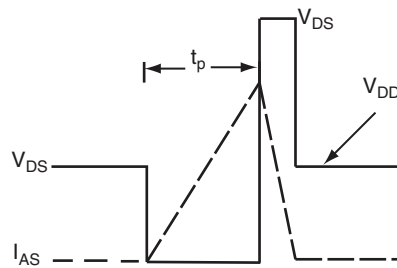
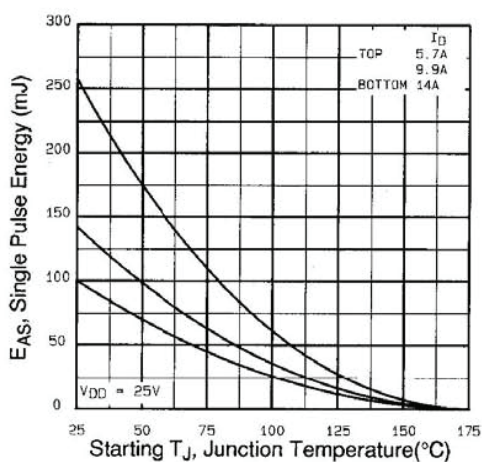
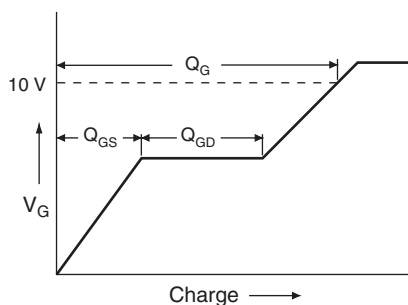
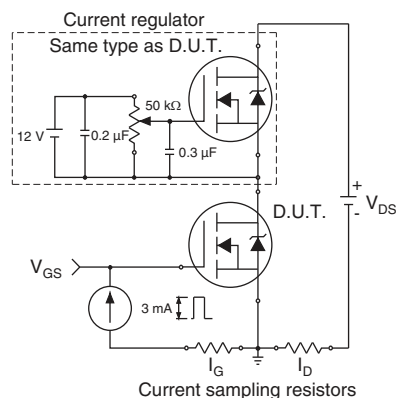
**Fig. 10a - Switching Time Test Circuit**

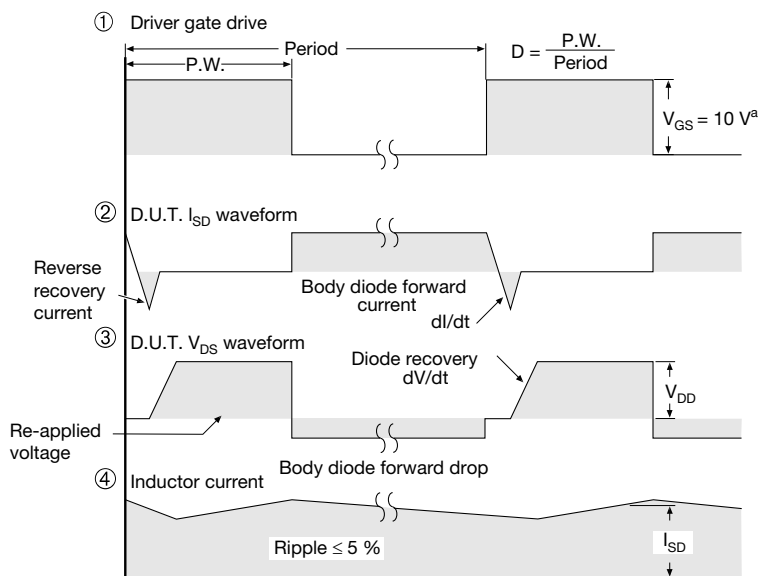
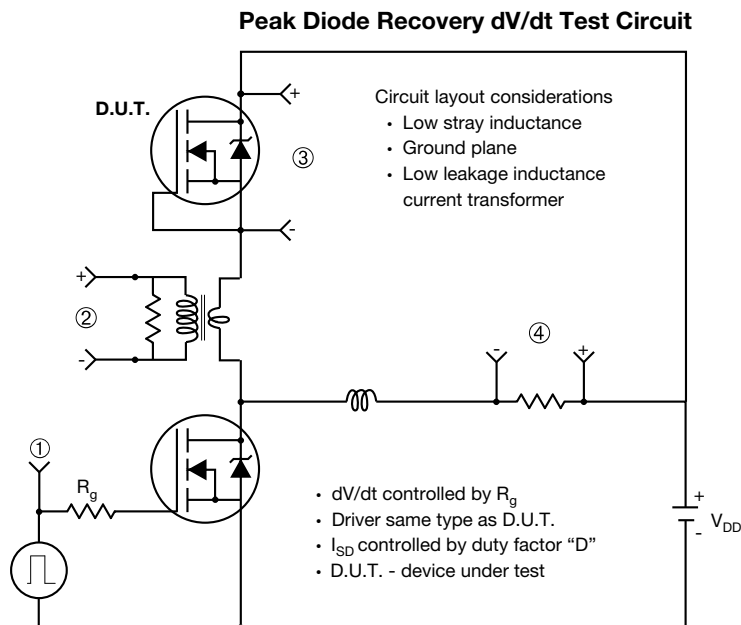


**Fig. 10b - Switching Time Waveforms**



**Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case**


**Fig. 12a - Unclamped Inductive Test Circuit**

**Fig. 12b - Unclamped Inductive Waveforms**

**Fig. 12c - Maximum Avalanche Energy vs. Drain Current**

**Fig. 13a - Basic Gate Charge Waveform**

**Fig. 13b - Gate Charge Test Circuit**



#### Note

a.  $V_{GS} = 5 V$  for logic level devices

**Fig. 14 - For N-Channel**

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## TO-220 FULLPAK (High Voltage)

### OPTION 1: FACILITY CODE = 9



| DIM. | MILLIMETERS |       |       |
|------|-------------|-------|-------|
|      | MIN.        | NOM.  | MAX.  |
| A    | 4.60        | 4.70  | 4.80  |
| b    | 0.70        | 0.80  | 0.91  |
| b1   | 1.20        | 1.30  | 1.47  |
| b2   | 1.10        | 1.20  | 1.30  |
| C    | 0.45        | 0.50  | 0.63  |
| D    | 15.80       | 15.87 | 15.97 |
| e    | 2.54 BSC    |       |       |
| E    | 10.00       | 10.10 | 10.30 |
| F    | 2.44        | 2.54  | 2.64  |
| G    | 6.50        | 6.70  | 6.90  |
| L    | 12.90       | 13.10 | 13.30 |
| L1   | 3.13        | 3.23  | 3.33  |
| Q    | 2.65        | 2.75  | 2.85  |
| Q1   | 3.20        | 3.30  | 3.40  |
| Ø R  | 3.08        | 3.18  | 3.28  |

#### Notes

1. To be used only for process drawing
2. These dimensions apply to all TO-220 FULLPAK leadframe versions 3 leads
3. All critical dimensions should C meet  $C_{pk} > 1.33$
4. All dimensions include burrs and plating thickness
5. No chipping or package damage
6. Facility code will be the 1<sup>st</sup> character located at the 2<sup>nd</sup> row of the unit marking



## OPTION 2: FACILITY CODE = Y



| DIM. | MILLIMETERS |        | INCHES    |       |
|------|-------------|--------|-----------|-------|
|      | MIN.        | MAX.   | MIN.      | MAX.  |
| A    | 4.570       | 4.830  | 0.180     | 0.190 |
| A1   | 2.570       | 2.830  | 0.101     | 0.111 |
| A2   | 2.510       | 2.850  | 0.099     | 0.112 |
| b    | 0.622       | 0.890  | 0.024     | 0.035 |
| b2   | 1.229       | 1.400  | 0.048     | 0.055 |
| b3   | 1.229       | 1.400  | 0.048     | 0.055 |
| c    | 0.440       | 0.629  | 0.017     | 0.025 |
| D    | 8.650       | 9.800  | 0.341     | 0.386 |
| d1   | 15.88       | 16.120 | 0.622     | 0.635 |
| d3   | 12.300      | 12.920 | 0.484     | 0.509 |
| E    | 10.360      | 10.630 | 0.408     | 0.419 |
| e    | 2.54 BSC    |        | 0.100 BSC |       |
| L    | 13.200      | 13.730 | 0.520     | 0.541 |
| L1   | 3.100       | 3.500  | 0.122     | 0.138 |
| n    | 6.050       | 6.150  | 0.238     | 0.242 |
| Ø P  | 3.050       | 3.450  | 0.120     | 0.136 |
| u    | 2.400       | 2.500  | 0.094     | 0.098 |
| V    | 0.400       | 0.500  | 0.016     | 0.020 |

ECN: E19-0180-Rev. D, 08-Apr-2019  
DWG: 5972

### Notes

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4. All dimensions include burrs and plating thickness
5. No chipping or package damage
6. Facility code will be the 1<sup>st</sup> character located at the 2<sup>nd</sup> row of the unit marking



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